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APPLICATION FOR UNITED STATES PATENT

FOR

SYSTEM, DEVICE, AND METHOD FOR PRODUCING OPTICAL DATA STREAMS IN AN OPTICAL COMMUNICATION NETWORK

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SYSTEM, DEVICE, AND METHOD FOR PRODUCING OPTICAL DATA STREAMS IN AN OPTICAL COMMUNICATION NETWORK

FIELD OF THE INVENTION

The present invention relates generally to optical networking, and more particularly to producing optical data streams in an optical communication network.

BACKGROUND OF THE INVENTION

An optical data stream is typically produced by modulating an optical carrier. A laser generates an optical carrier at a predetermined wavelength, and an external modulator coupled to the laser output modulates the optical carrier according to a data signal applied to the external modulator. The resulting optical data stream can be carried over the optical communication network.

There are generally two types of lasers, namely fixed wavelength lasers and tunable lasers. A fixed wavelength laser is capable of generating an optical carrier at a single wavelength. A tunable laser is capable of generating an optical carrier at any of a number of wavelengths. Tunable lasers are generally more flexible than fixed wavelength lasers, but cost substantially more than fixed wavelength lasers.

In an optical communication network that supports M wavelengths, it is sometimes necessary or desirable to produce N optical data streams at N specific wavelengths (where N is less than M).

One way to accomplish this is to use N tunable lasers coupled to N external modulators. Each of the N tunable lasers is tuned to one of the N specific wavelengths, and each of N data sources is fed into one of the N external modulators. This produces N optical data streams at the N specific

wavelengths. An advantage of this solution is that it uses a relatively small amount of equipment. A disadvantage of this solution, however, is that it is expensive due to the use of tunable lasers.

Another way to accomplish this is to use M fixed wavelength lasers coupled to M external modulators. The N data signals are fed into those N external modulators that are associated with the N fixed wavelength lasers having the N specific wavelengths, for example, using a cross-connect switch. This produces N optical data streams at the N specific wavelengths. An advantage of this solution is that it is relatively inexpensive compared to the tunable laser solution. A disadvantage of this solution, however, is that is uses a relatively large amount of equipment.

SUMMARY OF THE INVENTION

In accordance with one aspect of the invention, M fixed wavelength lasers and N external modulators ($N < M$) are used to produce N optical data streams. The M fixed wavelength lasers are coupled to the N external modulators through a photonic cross-connect switch that is capable of routing the outputs of any N of the M fixed wavelength lasers to the N external modulators. The photonic cross-connect switch is configured to route N optical carriers at N specific wavelengths to the N external modulators. N data signals are fed to the N external modulators for producing N optical data streams at the N specific wavelengths. The photonic cross-connect switch maintains the polarity of the N optical carriers that are routed to the N external modulators.

In accordance with another aspect of the invention, a photonic cross-connect switch includes polarization maintaining means for maintaining the polarity of optical carriers routed from any N of M optical inputs to N optical outputs. In a typical embodiment, polarization maintaining fibers are used

for coupling M optical inputs to a photonic cross-connect fabric and for coupling N optical outputs to the photonic cross-connect fabric.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and advantages of the invention will be appreciated more fully from the following further description thereof with reference to the accompanying drawings wherein:

FIG. 1 is a system diagram showing an exemplary optical communication system in which N tunable lasers and N external modulators are used to produce N optical data streams at N specific wavelengths, as is known in the art;

FIG. 2 is a system diagram showing an exemplary optical communication system in which M fixed wavelength lasers and M external modulators are used to produce N optical data streams at N specific wavelengths, as is known in the art;

FIG. 3 is a system diagram showing an exemplary optical communication system in which M fixed wavelength lasers and N external modulators are used in conjunction with a MEMS (Micro Electro Mechanical System) to produce N optical data streams at N specific wavelengths, in accordance with an embodiment of the present invention;

FIG. 4 is a block diagram showing the relevant logic blocks of the MEMS in accordance with an embodiment of the present invention; and

FIG. 5 is a system diagram showing an exemplary communication system for producing four optical data streams at any four of sixteen wavelengths, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

As discussed above, in an optical communication network that supports M wavelengths, it is sometimes necessary or desirable to produce N

optical data streams at N specific wavelengths (where N is less than M). An embodiment of the present invention uses M fixed wavelength lasers and N external modulators to produce the N optical data streams. The M fixed wavelength lasers are coupled to the N external modulators through a photonic cross-connect switch. The photonic cross-connect switch includes at least M optical inputs that are coupled to the outputs of the M fixed wavelength lasers, and also includes at least N optical outputs that are coupled to the inputs of the N external modulators. Within the photonic cross-connect switch, the M optical inputs are coupled to the N optical outputs through a photonic cross-connect fabric that is capable of routing any N of the M optical inputs to the N optical outputs. The photonic cross-connect fabric may be based upon Micro Electro Mechanical System (MEMS) technology, Micro Opto Electro Mechanical System (MOEMS) technology, bubble (champagne) technology, lithium niobate technology, liquid crystal technology, or other photonic switching technology. Optical connections within the photonic cross-connect switch (e.g., from the M optical inputs to the photonic cross-connect fabric and from the photonic cross-connect fabric to the N optical outputs) preferably use polarization maintaining (PM) fiber in order to maintain the polarity of the optical carriers from input to output. In order to produce N optical data streams at N specific wavelengths, the photonic cross-connect switch is configured to route those N optical inputs having the N specific wavelengths to the N optical outputs. The N data signals are fed into the N external modulators. This produces N optical data streams at the N specific wavelengths using M fixed wavelength lasers and N external modulators.

FIG. 1 shows an exemplary optical communication system 100 in which N tunable lasers and N external modulators are used to produce N optical data streams at N specific wavelengths, as is known in the art. The output of each of the N tunable lasers 102_1-120_N is coupled to the input of one of the N external modulators 104_1-104_N. Each of the N tunable lasers 102_1-120_N is tuned to one of the N specific wavelengths, and each of N data sources 106_1-106_N is

fed into one of the N external modulators 104_1-104_N. This produces N optical data streams 108_1-108_N at the N specific wavelengths.

FIG. 2 shows an exemplary optical communication system 200 in which M fixed wavelength lasers and M external modulators are used to produce N optical data streams at N specific wavelengths, as is known in the art. The output of each of the M fixed wavelength lasers 202_1-202_M is coupled to the input of one of the M external modulators 204_1-204_M. A digital cross-connect switch 210 is coupled between the N data signals 206_1-206_N and the M external modulators 204_1-204_M. The digital cross-connect switch 210 is capable of routing the N data signals 206_1-206_N to any N of the M external modulators 204_1-204_M. The digital cross-connect switch 210 is configured to route the N data signals 206_1-206_N to those N of the M external modulators 204_1-204_M that are associated with those N of the M fixed wavelength lasers 202_1-202_M having the N specific wavelengths. This produces N optical data streams 208_1-208_N at the N specific wavelengths.

FIG. 3 shows an exemplary optical communication system 300 in which M fixed wavelength lasers and N external modulators are used to produce N optical data streams at N specific wavelengths. The outputs of the M fixed wavelength lasers 302_1-302_M are coupled to the optical inputs of the photonic cross-connect switch 310, and the outputs of the photonic cross-connect switch 310 are coupled to the inputs of the N external modulators 304_1-304_N. The photonic cross-connect switch 310 is configured to route the outputs of those N of the M fixed wavelength lasers 302_1-302_M having the N specific wavelengths to the inputs of the N external modulators 304_1-304_N. Each of N data sources 306_1-306_N is fed into one of the N external modulators 304_1-304_N. This produces N optical data streams 308_1-308_N at the N specific wavelengths.

FIG. 4 is a block diagram showing the relevant components of the photonic cross-connect switch 310. Among other things, the photonic cross-connect switch 310 includes at least M optical inputs 402_1-402_M that are

coupled to a photonic cross-connect fabric 406 via PM fibers 404_1-404_M. The photonic cross-connect switch 310 also includes at least N optical outputs 410_1-410_N that are coupled to the photonic cross-connect fabric 406 via PM fibers 408_1-408_N. The photonic cross-connect fabric 406 is capable of routing any N of the M optical inputs 402_1-402_M to the N optical outputs 410_1-410_N. The photonic cross-connect switch 310 maintains the polarity of the optical carriers that are switched from the N of the M optical inputs 402_1-402_M to the N optical outputs 410_1-410_N.

FIG. 5 shows an exemplary optical communication system 500 for producing four optical data streams at any four of sixteen wavelengths. The outputs of sixteen fixed wavelength lasers 502_1-502_{16}, which produce fixed wavelengths λ_1-λ_{16}, respectively, are coupled to the inputs of the photonic cross-connect switch 510. The outputs of the photonic cross-connect switch 510 are coupled to the inputs of four external modulators 504_1-504_4. The photonic cross-connect switch 510 is capable of routing the outputs of any four of the sixteen fixed wavelength lasers 502_1-502_{16} to the four external modulators 504_1-504_4. In this example, the photonic cross-connect switch 510 is configured to route the output of fixed wavelength laser 502_2 (λ_2) to external modulator 504_1, route the output of fixed wavelength laser 502_6 (λ_6) to external modulator 504_2, route the output of fixed wavelength laser 502_{10} (λ_{10}) to external modulator 504_3, and route the output of fixed wavelength laser 502_{14} (λ_{14}) to external modulator 504_4. Data signal 506_1 is fed to external modulator 504_1 to produce optical data stream 508_1 at wavelength λ_2. Data signal 506_2 is fed to external modulator 504_2 to produce optical data stream 508_2 at wavelength λ_6. Data signal 506_3 is fed to external modulator 504_3 to produce optical data stream 508_3 at wavelength λ_{10}. Data signal 506_4 is fed to external modulator 504_4 to produce optical data stream 508_4 at wavelength λ_{14}.

It should be noted the photonic cross-connect switch (310, 510) preferably maintains the polarity of each optical carrier from input to output.

In exemplary embodiments of the invention, PM fibers are used to maintain the polarity of optical carriers from input to output within the photonic cross-connect switch. However, alternative techniques for maintaining the polarity of optical carriers from input to output within the photonic cross-connect switch may also be used, and are intended to fall within the scope of the present invention.

The present invention may be embodied in other specific forms without departing from the true scope of the invention. The described embodiments are to be considered in all respects only as illustrative and not restrictive.